

Service users may be more likely to have diseases associated with sexual activity and thus be more likely to adopt behaviors thought to limit infection. This may account for the differences in associations when cases are compared to student population rather than Health Service controls. Cases and controls completed the same questionnaires minimizing any misclassification with respect to exposure. Because case status was based solely on clinical diagnosis, undoubtedly some misclassification of disease occurred. However, the bias should have been at random, biasing the results toward no difference between groups.

This study showed a strong association between sexual intercourse and vulvovaginal candidiasis among non-pregnant women. Other suggested factors—wearing tight clothing, hose or synthetic underwear; type of menstrual protection; use of feminine hygiene sprays; and diet—were not associated with candidiasis. Most women with recurring vulvovaginal candidiasis tend to avoid all suggested risk factors,¹ which do not include sexual intercourse. Although these findings need confirmation, suggesting to women suffering recurring vulvovaginal candidiasis that they temporarily decrease frequency of sexual intercourse has more

scientific basis than some of the other standard advice (wear cotton underwear), would do no harm, and might potentially avoid recurrence.

ACKNOWLEDGEMENTS

The author thanks the University of Michigan Health Service for their support of this study. Without the efforts of the triage nurses who distributed the questionnaires, the study would not have taken place.

This work was supported, in part, by grant #DK35368 from the National Institute of Diabetes, Digestive and Kidney Diseases.

REFERENCES

1. Sobel JD: Epidemiology and pathogenesis of recurrent vulvovaginal candidiasis. *Am J Obstet Gynecol* 1985; 152:924-935.
2. Leegaard M: The incidence of candida albicans in the vagina of healthy young women. *Acta Obstet Gynecol Scand* 1984; 63:85-89.
3. Foxman B, Chi JW: Health behavior and urinary tract infection. *J Clin Epidemiol* (in press) 1990.
4. Schlesselman JJ: Case-control studies: design, conduct, analysis. New York: Oxford University Press, 1982; 171-290.
5. Kleinbaum DG, Kupper LL, Morgenstern H: Epidemiologic Research: Principles and Quantitative Methods. Belmont: Lifetime Learning Publications, 1982; 321-376, 458-491.
6. Fleury FJ: Adult vaginitis. *Clin Obstet Gynecol* 1981; 24:407-438.

Recurring Urinary Tract Infection: Incidence and Risk Factors

BETSY FOXMAN, PhD

Abstract: Urinary tract infection (UTI) is a common infection among young women, with a high recurrence rate. This study documents the six-month incidence of second UTI among a cohort of women with one initial UTI and the factors associated with recurrence. Among the cohort of 113 women, 30 (26.6 percent) experienced at least one culture-confirmed recurrence within the six months following initial infection. The presence of hematuria and urgency as symptoms of initial infection were the strongest predictors of second infection. Behavioral factors associated with initial infection (frequency of sexual intercourse, diaphragm use, and voiding after sexual intercourse) did not distinguish between women who would and would not experience a second UTI during the six-month follow-up period. (*Am J Public Health* 1990; 80:331-333.)

Introduction

Urinary tract infection occurs frequently among young women, with over one-fourth having a second infection.¹ Why otherwise healthy women with no known anatomical abnormalities have multiple recurrences is a subject of some controversy, although both host and agent characteristics have been suspected. However, most authors would agree with Kunin's statement that the risk of a second infection is

greater than the first, and that the first "sets the stage" for recurring infection.²

Methods

All cases of first UTI among college women enrolled in a previously described case-control study* were eligible to participate in the follow-up study. A UTI was defined as the presence of significant bacteriuria ($\geq 10,000$ colonies of a single bacteria per milliliter urine) and one or more urinary symptoms: hematuria, dysuria, frequency, urgency, or suprapubic pressure. Urinalyses and urine cultures were performed on all women presenting with urinary symptoms using standard techniques.* History of UTI was assessed by review of medical records and self-report.

Prior to enrollment, participants completed a self-administered questionnaire which contained a consent form approved by the University of Michigan Institutional Review Board and questions on medical history, stress, clothing, diet, sexual activity, and birth control method. Responses to questions regarding birth control method, sexual activity, history of UTI, and demographics and the presence of UTI were confirmed by review of medical records. At the end of the six-months follow-up, participants' medical records were again reviewed to record the number and timing of UTIs treated.

Symptoms (frequency, dysuria, nocturia, urgency, hematuria, fever, chills, back or flank pain, and any other symptoms specified by the respondent), costs of treatment, measures of disease impact, and whether a woman had changed her health habits following the UTI were assessed via a self-administered questionnaire sent to all participants two weeks following enrollment.

Since bacteria normally found in the intestine cause the majority of UTIs in this age group, a woman may be

Address reprint requests to Betsy Foxman, PhD, Assistant Professor, Department of Epidemiology, School of Public Health, University of Michigan, 109 Observatory Street, Ann Arbor, MI 48103. This paper, submitted to the *Journal* April 17, 1989, was revised and accepted for publication August 1, 1989.

*Foxman B, Chi JW: Health behavior and urinary tract infection 1990; *J Clin Epidemiol* (in press).

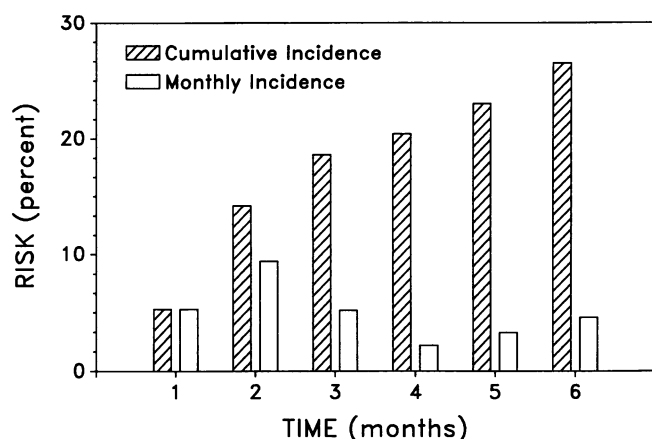


FIGURE 1—Monthly and Cumulative Incidence of Second Urinary Tract Infection (UTI) among a Cohort of 113 Women with One Prior UTI

re-infected with identical bacteria making it difficult to distinguish relapse from recurrence even in the presence of sophisticated bacteriologic techniques. As such techniques were not used in this study, I defined a recurrent urinary tract infection as the presence of $\geq 10,000$ col/ml of a single bacteria and one or more urinary symptoms occurring at least two weeks after the initial infection. This may lead to some misclassification of outcome; however, as long as the classification is not associated with the exposure(s) of interest the resulting measures of association should be biased toward the null hypothesis of no difference.

The associations between hypothesized risk factors and repeat UTI were studied using multilevel contingency tables, with both stratification and multivariate techniques to control for confounding.³ I calculated six-month cumulative incidences of UTI, risk ratios (RR), and Mantel-Haenszel summary RRs. Exact 95 percent confidence intervals (CI) were calculated around each RR using the method of Gart.⁴

A three-level symptoms scale, (0 = no hematuria or urgency, 1 = urgency alone, 2 = hematuria and urgency) was developed and used both as a dependent and independent

variable in the analysis. When used as a dependent variable, I tested the hypothesis that the relationship was linear and the slope zero with a chi square test for trend.⁵ Linear regression models with number of culture confirmed repeat UTIs and with the symptom scale as dependent variables were also fit to the data.

Results

The study cohort consisted of 113 women ages 17 to 39 (mean 21.3 years) with a first UTI. None of the participants had pyelonephritis, nor concurrent infection with gonorrhea, herpes, or chlamydia. The majority were White (83.8 percent), single (90.1 percent), and did not have a private physician (other than at the Health Service) within driving distance of their current residence (71.2 percent). Most had sexual intercourse during the four weeks prior to their first UTI (94.6 percent).

The six-month risk of a second UTI was 26.6 percent; the risk of a third UTI, 2.7 percent. Figure 1 shows the distribution of second infections; the median time to recurrence was approximately two months (56 days).

The presence of hematuria and/or urgency as symptoms of first infection was the strongest predictor of second infection (Table 1). Although the confidence intervals around the risk ratios include 1.0 (no difference), a significant relationship between symptoms and second infection was observed using a linear regression model including age as an independent variable (linear regression coefficient: 0.149, SE = 0.064). Other symptoms—fever, chills, flank or back pain, frequency, nocturia, or dysuria—were not associated with second infection.

Frequency of sexual intercourse, diaphragm use, and voiding around sexual intercourse were only weakly associated with second infection (Table 1). The trend in decreasing proportion of second infections with voiding after sexual intercourse is of interest (linear regression coefficient: -0.033; SE = 0.033).

Neither frequency of sexual intercourse, diaphragm use, nor voiding after sexual intercourse were associated with the presence of urgency and hematuria at first infection. However, increasing age was negatively associated with increas-

TABLE 1—Factors Associated with Second Urinary Tract Infection among College Women

Factors	Number	Percent Recurring	RR (95% CI)
<i>Symptoms of initial infection*</i>			
<i>Symptom scale</i>			
no urgency or hematuria	22	13.6	1.0 (reference)
urgency alone	38	21.1	1.5 (0.5, 5.2)
urgency and hematuria	47	38.3	2.8 (0.9, 8.5)
<i>Behaviors during four weeks prior to initial infection</i>			
<i>Frequency of sexual intercourse†</i>			
<1 times per week	20	25.0	1.0 (reference)
1–2 times per week	38	21.0	0.8 (0.3, 2.2)
3 or more times per week	52	30.8	1.2 (0.5, 2.9)
<i>Birth control method (sexually active women only)</i>			
Oral contraceptives	47	25.5	1.0 (reference)
Diaphragm use	22	31.8	1.2 (0.6, 2.7)
Other	36	25.0	1.0 (0.5, 2.1)
<i>Voiding after sexual intercourse (sexually active women only)</i>			
Never/rare	36	33.3	1.0 (reference)
Sometimes	34	26.5	0.8 (0.4, 1.8)
Frequently/always	35	20.0	0.7 (0.3, 1.5)

*Two women had hematuria alone, four had missing data.

†Three women had missing data.

ing symptoms (linear regression coefficient: -0.012 ; $SE = 0.013$).

Discussion

In this study, factors observed to be associated with UTI in previous studies⁶⁻⁹—frequency of sexual intercourse, diaphragm use, and voiding after sexual intercourse—did not predict recurrence in the next six months. The strongest predictors were characteristics of the infection itself: the presence of hematuria and urgency. Indeed, the six-month risk of second infection was three times higher among women with both, compared to neither, symptom (13.6 percent vs 38.3 percent). This suggests that it is the characteristics of the bacteria causing the initial infection and the extent of infection which predict recurrence.

Since I depended upon medical records for report of recurrence in a fairly mobile population, the risk of second UTI was probably underestimated. Moreover, sophisticated bacteriologic techniques were not used, making it impossible to determine how a particular bacteria and associated virulence factors might set the stage for recurrence. However, the results imply that future studies should examine bacterial and host characteristics as well as health behaviors to better understand the etiology of recurring UTI.

In conclusion, among this cohort of college women with initial UTI, demographic and behavioral factors did not distinguish between women who would and would not experience a second UTI during the six-month follow-up period. The strongest predictor of second infection was the presence of hematuria and urgency as symptoms of initial UTI. Future

studies should use consider both behavioral and bacterial characteristics as potential determinants of recurring UTI.

ACKNOWLEDGMENTS

The author thanks the University of Michigan Health Service for support of this study. Without the efforts of the triage nurses who distributed the questionnaires, the study would not have taken place. Thanks also to colleagues James Koopman and Carl Marrs for helpful comments on earlier drafts of this manuscript, and to research assistants Ana Carriazo, Patricia Crawford, Carl Li, D. Rebecca Prevots, Cynthia Rusk, and Ellen Ward for their help in coordinating and managing the study. This work was supported by grant #DK35368 from the National Institute of Diabetes, Digestive and Kidney Diseases.

REFERENCES

1. Stamey TA: Pathogenesis and Treatment of Urinary Tract Infections. Baltimore: Williams & Wilkins, 1980.
2. Kunin CM, Polyak F, Postel E: Periurethral bacterial flora in women: prolonged intermittent colonization with *Escherichia coli*. JAMA 1980; 243:134-139.
3. Schlesselman JJ: Case-control Studies: Design, Conduct, Analysis. New York: Oxford University Press, 1982.
4. Sullivan K, Foster D: dEPID, A program for stratified and standardized analysis, Version 2.1. Roswell: Epidemiology Monitor, 1987.
5. Fleiss JL: Statistical Methods for Rates and Proportions, 2d Ed. New York: Wiley, 1981.
6. Foxman B, Frerichs RR: Epidemiology of urinary tract infection: I. Diaphragm use and sexual intercourse. Am J Public Health 1985; 75:1308-1313.
7. Remis RR, Gurwith MJ, Gurwith D, Hargrett-Bean NT, Layde PM: Risk factors for urinary tract infection. Am J Epidemiol 1987; 126:685-694.
8. Strom BL, Collins M, West SL, Kreisberg J, Weller S: Sexual activity, contraceptive use, and other risk factors for symptomatic and asymptomatic bacteriuria. Ann Intern Med 1987; 107:816-823.
9. Fihn SD, Latham RH, Roberts P, Running K, Stamm WE: Association between diaphragm use and urinary tract infection. JAMA 1985; 254:240-245.

Potential for Lyme Disease in Maine: Deer Survey of Distribution of *Ixodes dammini*, the Tick Vector

ROBERT P. SMITH, JR, MD, MPH, PETER W. RAND, MD, AND ELEANOR H. LACOMBE, BS, MT (ASCP)

Abstract: A survey of deer brought to tagging stations at 24 sites in Maine revealed the presence of the deer tick, *Ixodes dammini*, on 5.1 percent of deer. Ticks were found almost exclusively on deer from southwest coastal sites in the state. The potential for endemic Lyme disease in coastal Maine merits further study. (Am J Public Health 1990; 80:333-335.)

Introduction

The current geographic range of *Ixodes dammini*, the principal vector of Lyme disease in the eastern United States, is incompletely established. Continued spread of *I. dammini* in coastal New England accounts for new foci of Lyme disease in previously non-endemic areas.^{1,2} Recent studies document the rapid rise of Lyme disease prevalence in some areas following colonization by the deer tick.¹ As public

education remains the primary means of prevention of Lyme disease, knowledge of the regional distribution of the vector ticks enables targeted surveillance and focused public health interventions. Prior to 1985, there were no records of *Ixodes dammini* from Maine.* Although Maine has been considered a non-endemic area for Lyme disease, infected *I. dammini* were recently reported from one coastal Maine site³ and *I. dammini* have been found on a deer shot in a northern inland site.⁴ Three locally acquired seropositive cases of Lyme disease meeting Centers for Disease Control (CDC) criteria were reported to the Maine Bureau of Health between 1986 and 1988. We undertook a survey of ticks on deer brought to Maine tagging stations in 1988 to further describe the distribution of *I. dammini* at its northeastern limit in the United States.

Methods

Twenty-four deer tagging stations were selected for surveillance throughout Maine in consultation with state

Address reprint requests to Robert P. Smith, Jr, MD, MPH, Research Department, Maine Medical Center, 22 Bramhall Street, Portland, ME 04102. Dr. Rand is Director of the Department; the Maine Medical Center is a teaching hospital of the University of Vermont College of Medicine. This paper, submitted to the Journal May 19, 1989, was revised and accepted for publication August 9, 1989.

*Dearborn R: Personal communication. Department of Conservation, State of Maine.